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Fluctuations in the Abundance of Striped Bass (*Roccus lineatus*) in California

By
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Fluctuations in the Abundance of Striped Bass (*Roccus lineatus*) in California[1]

By G. H. Clark

INTRODUCTION TO THE ANALYSIS OF BOAT CATCHES

Fluctuations in the available supply of striped bass in the San Francisco Bay and Sacramento-San Joaquin river regions for the years 1920-1927 were shown in a bulletin (by Craig, 1930) published by the California Division of Fish and Game. The present report is a continuation of that study of the striped bass, which covers the period January 1, 1928 to August 14, 1931. On August 14, 1931, it became unlawful to catch striped bass by means of nets except when accidentally taken in shad nets in District 12B, between March 15 and April 30, inclusive.

Conclusions of the previous report by Craig are in part: "If all conditions affecting the striped bass continue to remain the same the striped bass population could continue to support this fishery without injury to the supply . . . . Therefore, while there is no evidence of depletion apparent up to 1927 and the striped bass supply seems well able to support its commercial fishery as long as other conditions remain constant, it would be well to carry on the study of the fluctuations in abundance of the striped bass from year to year in order that the effect of any factor which might dangerously diminish the striped bass supply might be detected."

There is little need to recount the past history of the striped bass fishery as Craig (1930) and Scofield (1931) have already covered this phase adequately in previous publications. Our concern is primarily with the commercial catch statistics from January 1, 1928 to August 14, 1931. The total catch of striped bass in California is shown in figure 1 and numerically in table 1. It will be noticed that the year 1928 was the lowest in the entire history of the fishery, with 1929 only slightly higher. On the other hand, the 1930 catch made a tremendous increase over the two previous years, equaling the total catch of 1925. In 1931 (January 1-August 14) the total catch was about 780,000 pounds, slightly less than the total for 1930. The total catch for the entire year of 1931 (including commercial hook and line caught fish after netting was prohibited on August 14) was the greatest since 1918, reaching a total of 950,000 pounds.

Total catch figures, when unsupported by other factors which in some degree show the effort put forth, do not show as a rule the true fluctuations in abundance of a species of fish. Changing conditions in a fishery, such as the increase or decrease in the number of fishermen,

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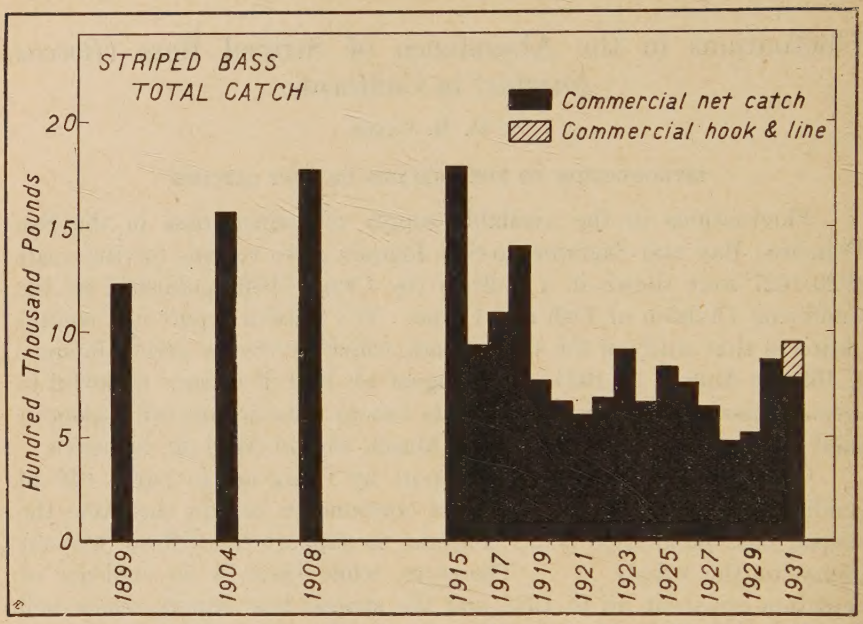

FIG. 1. Total catch of striped bass in California for the period 1899–1931. All the striped bass in California, except approximately 100 pounds, were taken in the San Francisco Bay and Sacramento-San Joaquin river regions.

TABLE I

Year	Total catch	Year	Total catch
1915	1,784,448	1924	661,777
1916	941,849	1925	837,773
1917	1,095,856	1926	750,801
1918	1,407,841	1927	647,594
1919	768,934	1928	484,113
1920	671,747	1929	528,981
1921	601,614	1930	866,808
1922	684,198	1931	950,191
1923	909,573		

restrictive legislation, or a change in fishing gear or methods, may materially affect the total catch, but such changes can be accounted for and the accurate fluctuations in fish supply can be shown by determining the yield of fish per unified effort. Such a measure is comparable from year to year.

The source of material used in this study was the same as employed in the previous striped bass catch analysis work—the daily boat catches of the commercial striped bass fishermen. The daily catch of each boat, using a net for bass or shad, was recorded in pounds both for striped bass and shad for the years 1928, 1929, 1930, and to August 14, 1931. Data were recorded by days and months, care having been taken to keep the first half and last half of each month separate for later analysis. After the data were all recorded for each year a random sample of every

second daily striped bass boat catch was taken for each year together with the number of catches. This random catch sample was totaled for each year and then divided by the number of catches making up the respective year's total. The result is the average boat catch per day's

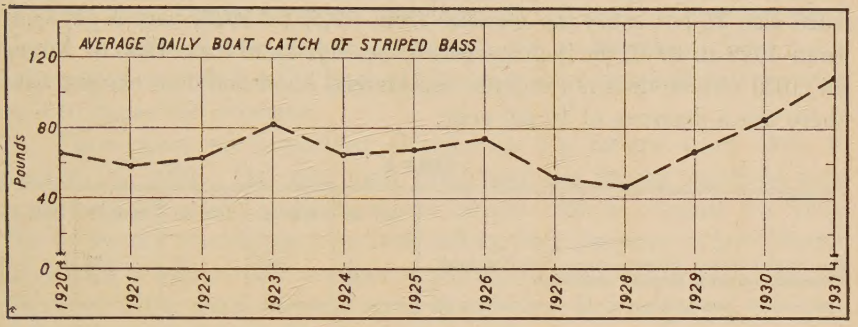

FIG. 2. Average daily boat catch of striped bass (in pounds) calculated for the years 1920–August 14, 1931, using every second striped bass catch.

fishing for each of the years 1928, 1929, 1930, and 1931 (to August 14). Similar compilations and calculations had been made by Craig for the years 1920 to 1927, inclusive. The average daily boat catch for striped bass for the years 1920 to August 14, 1931, is shown in table 2 and in figure 2.

TABLE 2

Year	Average daily boat catch of striped bass in pounds
1920	66
1921	58
1922	63
1923	82
1924	65
1925	68
1926	74
1927	52
1928	47
1929	67
1930	85
1931	109

Those familiar with the work of Craig will recognize the curve showing the average catch per boat for the years 1920 to 1927, inclusive, at which point his study terminated. In 1928 the boat catch was at its lowest point in the series of years from 1920 to 1931. (See fig. 2.) The 1929 catch, however, recovered and almost equaled that of 1925. The years 1930 and 1931 showed tremendous increases in the daily average boat catch. Both averages were larger than for any preceding year for which boat catch data were available. The percentage decrease from 1927 to 1928 was approximately 10 per cent. The percentage increase

from 1928 to 1929 was 43 per cent; from 1929 to 1930, 27 per cent; and from 1930 to 1931, 28 per cent. From 1928 (the low point) to 1931, the percentage increase was 132 per cent. When these percentage decreases and increases are compared to those of the total catch the results are somewhat different. The percentage decrease in total catch from 1927 to 1928 was 25 per cent; the increase from 1928 to 1929, was 9 per cent; from 1929 to 1930, the increase was 64 per cent; and from 1930 to August 14, 1931 (which does not include commercial hook and line caught fish), there was a decrease of 10 per cent.

TABLE 3

	1927–28	1928–29	1929–30	1930–31	1928–31
Percentage increase or decrease—average daily boat catch	−10	+43	+27	+28	+132
Percentage increase or decrease—total catch	−25	+9	+64	−10	+61

Table 3 contrasts the percentage loss and gain of the average daily boat catch and of the total catch. This contrast is presented in order to show the different results obtained from the two uses of the data. For instance, the average daily boat catch showed an increase of 28 per cent between 1930 and August 14, 1931, while the total catch showed a decrease of 10 per cent for the same period. The reason for this difference is obvious. The value for 1930 is an average for the entire year and the value for 1931 is an average of all catches to August 14, on which date netting was prohibited by law. Whether or not the average would have been different if commercial netting had been allowed to continue, will never be known. However, the total catch for 1930 includes the entire year's catch, while for 1931, the catch to August 14 only is included. Consequently the 1930 and 1931 total catch data are not comparable, but the boat catch data for 1930 and 1931 are comparable with certain restrictions when expressed as averages as will be shown later.

YIELD BY UNIT OF EFFORT

Aside from the incomparable data (1930 with 1931), various other factors make some of the preceding years' total catch unlike those of later years. Craig (1930, p. 9 and fig. 2) explains how successive restrictive measures lessened the fishing time as well as the fishing area. Consequently the total catch for 1918 would not be comparable with 1927, even if other conditions, aside from restrictive laws, had remained constant. No restrictive measures were passed by the State Legislature after 1927 until 1931, in which year commercial netting was prohibited. These factors which affect total catch to such an extent make it essential that some measure be used to express the catch per unit of effort expended.

For the four years considered in this present study, the number of boats engaged in the fishery did not vary a great deal but fluctuated between 280 and 250 boats per year, the largest number fishing in 1928. It would appear that the effort put forth as far as number of boats are concerned did not vary greatly for any of these years, but such a measure of effort does not account for the intensity of boats fishing during a season or parts of any season. However, the average daily boat catch does partly account for the intensity because the number of catches were used to figure the averages.

There were no important changes in the fishery from 1928 to August 14, 1931. The gear (gill nets) and the fishing methods were practically the same throughout the period 1920 to August 14, 1931. The fishermen concentrated on bass fishing from January to late March, using bass nets, and then a majority shifted to shad fishing until May 15 (the end of the shad season), using shad nets. It was during this part of the season (late March to May 15) that the greatest number of catches of striped bass were made, but they were small catches. During August and the first half of September the fishermen concentrated on striped bass and salmon. Although relatively few catches of striped bass were made, they were large catches. From November 15 to December 31 (inclusive), the nets were laid out for striped bass, the size of catches and the number of catches being about the same as in the previous open period. From May 16 to July 31 (inclusive) and from September 16 to November 15 (inclusive), the fishery was closed to commercial striped bass fishing.

SEASONAL CHANGES

The average daily boat catch by half-month periods for the 12 years (1920 to August 14, 1931) and the averages for the same periods for 1928, 1929, 1930, and to August 14, 1931, are shown in figure 3 and in table 4. It is noted from figure 3 that the size of catch in the average or normal season of size of catch was low during the half-month periods 1 to 9, corresponding to January 1-May 15, while the lowest catch occurred in periods 6 and 7, corresponding to March 16-April 15. Periods 10, 11 and 12 (August 1-September 15) showed the highest catches, while periods 13, 14 and 15 (November 15-December 31) showed high catches but less than for the previous three periods.

The average (12-year average) or normal number of catches is shown in figure 4, by half-month periods, together with the number of catches for 1928 to August 14, 1931, for the same periods. It will be noticed that the greatest number of catches occurred during periods 6, 7, 8, and 9 (March 16-May 15), while during the rest of the year the number were lower and about the same for each period.

If during periods of normally high catches, the catches for any season are above average, the arithmetic mean for that year will be higher

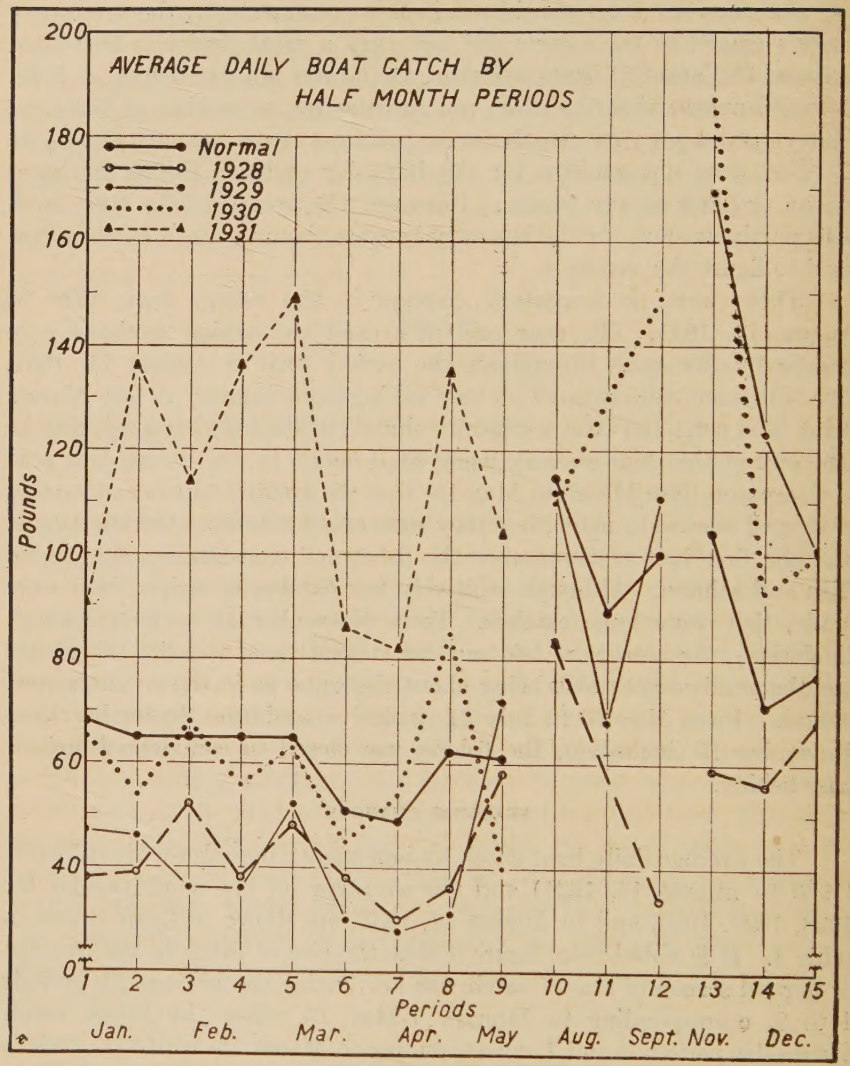

FIG. 3. Average daily boat catch of striped bass in pounds by half-month periods, showing seasonal changes in the normal or average season and in the years 1928–August 14, 1931.

than for a year when an equal percentage gain occurs during periods of normally low catches. This is due to the fact that equal percentage gains among high and low numbers necessitates a larger gain in actual value for the high numbers. Years having a greater than normal number of catches, occurring in periods of high catches, will tend to have a higher mean than years having a normal or less than average number of catches in seasons of large catches. Likewise, a year having more than the normal number of catches in periods of low catches will have the

TABLE 4

Periods	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Average boat catch (in pounds) per fishing day, normal year	68	65	65	65	65	51	49	62	61	115	89	100	104	71	77

TABLE 5

Periods	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Average number of boat catches per period—normal year	186	184	203	207	285	447	611	655	554	195	162	155	358	257	260

mean lowered even though the catches for the low periods are above normal. (See Craig, 1930, p. 16; and Clark, 1931, p. 32.)

Such variations in the seasonal catches are apt to cause errors in the yearly average. In order to guard against such errors the percentage deviation for each period from the corresponding period in the base or normal year was determined. It was for this reason that each year's data were divided into half-month periods and the average daily boat catch calculated for each period in each year. These calculations had been figured for the years 1920-1927 by Craig. The data for all years considered, 1920 to August 14, 1931, were used in determining the averages by periods for the base or normal year. The percentage deviations for each period in each year were calculated for all years from 1920 to August, 14, 1931. The data from 1920 to 1927 had to be recalculated because a new base year was used in this analysis. The method employed was the same as used by Craig (1930, p. 25) except that the percentage deviations for each period were weighted by the average or normal number of catches for that period as determined from the 12-year average (see table 6), instead of being weighted by the actual catches made in each period each year. The reason for this was the same as explained by Craig (1930, p. 28). The difference between the yearly percentage deviations from the base, comparing like seasonal parts and using actual weighting or average (normal) weighting, was very slight. However, the values obtained for the percentage deviations using normal weighting, all factors considered, best portray the yearly supply of striped bass available to the fishermen. A graph of these values compared to the average daily boat catch by years appears in figure 5.

TABLE 6

	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
Percentage deviation from normal, using average weighting	101	85	88	118	94	82	113	70	67	80	108	176

The values for the various years as shown by the percentage deviation and by the average daily boat catch methods were not strikingly unlike. Most of the differences were in 1925, 1926, 1928, and 1931 in their relation to other yearly values in each respective curve. The explanation for the change in 1925 and 1926 has been given by Craig (1930, pp. 27, 30, 31). The changes in 1928 and 1931 are explained in figure 3, where the average daily boat catch of striped bass is plotted for 1928 to August 14, 1931, by half-month periods, together with the 12-year average of each period. It will be noticed that the 1928 values were below average for the entire season. By referring to figure 4, showing the number of catches per period, it is seen that during periods 8 and 9 for 1928, the number of catches were considerably above normal. The abnormal number of catches occurring during a period of small catches, coupled with a below normal catch for the periods in 1928, made the arithmetic average low for 1928. (See fig. 5.) However, when the data for each year

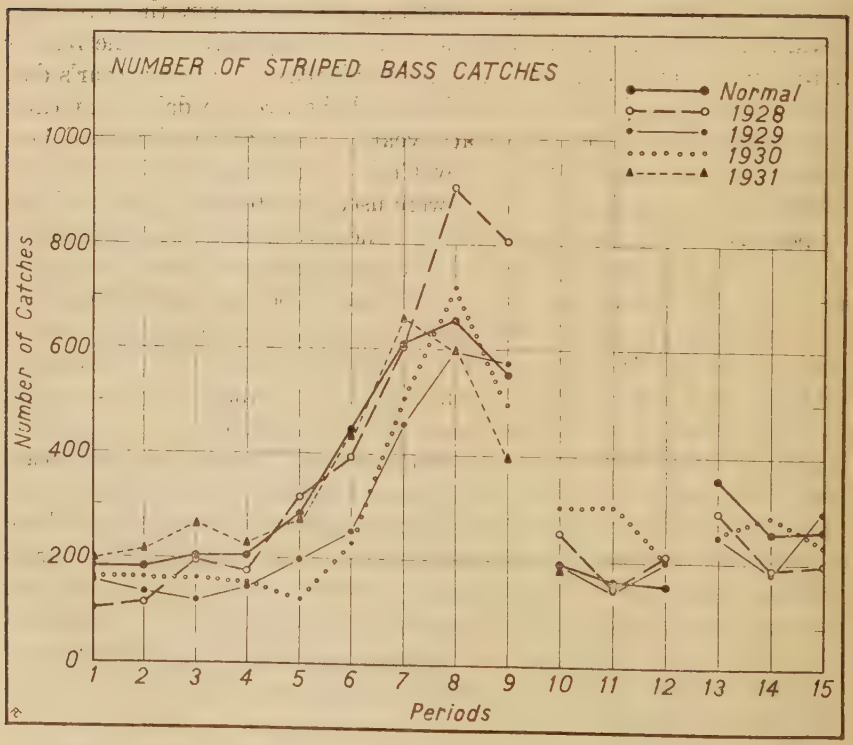

FIG. 4. Number of striped bass catches by half-month periods for the normal or average season and for 1928–August 14, 1931.

were expressed as a percentage deviation of the base or average year by periods and these percentage deviations were weighted by a normal or average number of catches, the value for the 1928 average daily boat

catch was somewhat higher in relation to other years and was certainly a more accurate measure of the available striped bass. The seasonal curve for 1931, although it contains data only for the first 10 periods, shows a decided increase over normal for each period from 1 to 9, whereas the number of catches were about normal for these periods. (See figs. 3 and 4.) Period 10 for 1931 comprised a normal number of catches but was below normal in size of catch. The increases in size of catches in this year were all in the periods of normally low catches; although the mean was high it was not as high as the increased size of catches warranted because of the low numbers. When the value for 1931 was calculated as a percentage deviation of the base by periods, the tremendous percentage gain over the base was noted. (See fig. 5.) The method of weighting either by actual catches or by normal number of catches will make little difference in this case as the two (actual and normal number of catches) were very similar. Whether or not the value for 1931 would have been changed much if net catch records had been available for the remainder of the season (periods 11-15) will never be known. (See fig. 3.) The fact that for period 10 (August 1-14) the catch was below normal or average is no indication of what the catch for the rest of the periods in the season might have been if comparable data had been available.

FACTORS INFLUENCING CATCH OTHER THAN ABUNDANCE

So far in this analysis we have obtained an average daily boat catch of striped bass wherein the catch was measured by a constant unit of time (day) and effort (boats using like gear from year to year). We have corrected for seasonal variations between years by obtaining the percentage deviations of each year by half-month periods from a base year. The effect of unusual conditions on the fishery such as strikes, inclement weather over a long period of time, or abnormally high or low number of catches in certain periods, have been eliminated by weighting the percentage deviations from the base by a normal number of catches for each period. The result of these calculations and corrections was a measure of the abundance of striped bass that were available to the fishermen each year during 1920 to August 14, 1931. (See fig. 5.) Certainly for the years 1929 to August 14, 1931, the striped bass population was able to support the fishery. The entire period from 1920 to August 14, 1931, shows a gradual upward trend of the average boat catch as illustrated by the straight line fitted to the curve. (See fig. 5.) The value for the data available in 1931 was the greatest of any year for which the boat catch data were used.

It has been demonstrated that there was an inverse ratio between the size of shad catches and the size of bass catches for corresponding days. (See Craig, 1930, p. 36.) This was also apparent in the data from 1928

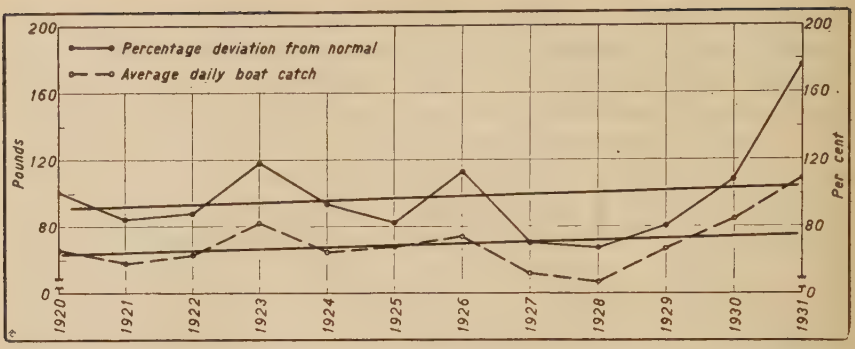

FIG. 5. Comparison of the percentage deviation from normal (using average weighting) with the average daily boat catches of striped bass for the years 1920–August 14, 1931. Notice the straight line trends fitted to each curve.

to August 14, 1931. Since this inverse effect occurred year after year and since we have corrected for seasonal changes within the season, the effect of the shad catch should not influence the bass curve greatly unless there was a very definite change in the fishery. For instance, if in any year during the regular shad season, the fishermen were to disregard shad and fish for bass, such an occurrence would show in the seasonal curve. Although the effect of shad on the striped bass curve seems to be negligible, in order to demonstrate further that the shad did not materially affect the striped bass catch, the striped bass catch data for the periods 7, 8 and 9 (April 1-May 15), which is the height of the shad season (see Clark, 1930, pp. 36, 38), were discarded. Then the percentage deviations from the base year by periods (omitting 7, 8 and 9) were recalculated and weighted by the normal number of catches, again discarding periods 7, 8 and 9. The percentage deviations for each year were determined. (See Craig, 1930, p. 35.) The result was plotted in figure 6, with the percentage curve in which periods 7 to 9 were included.

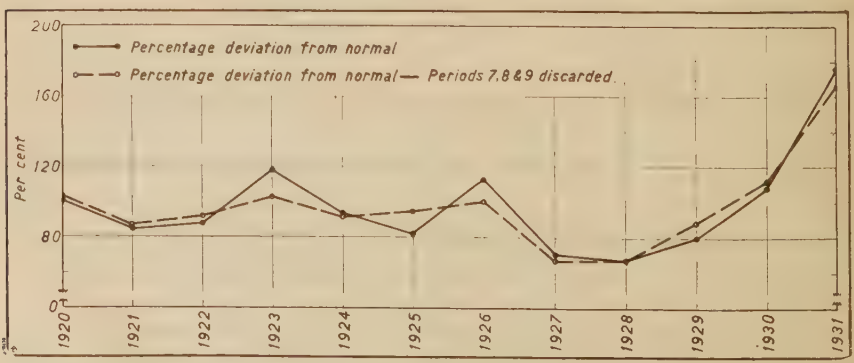

FIG. 6. Comparison of the percentage deviation from normal (using average weighting) with the percentage deviation from normal (using average weighting) in which data from periods 7, 8 and 9 (the shad season) were excluded.

TABLE 7

	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
Percentage deviation from normal year, using average weighting (Periods 7, 8 and 9 discarded)	103	87	92	103	92	95	101	67	67	89	112	166

It is noticed that there are small differences between the two curves and the outstanding fact is that the striped bass data from which the shad season was discarded did not change the shape or trend of the striped bass curve to any extent. Without doubt, we may feel certain that the effect of the shad catches on the measure of abundance of striped bass is of no consequence.

Prices are sometimes an incentive to the fishermen to expend greater effort, that is, they may put in longer hours or fish more gear. There seems to have been no such price incentive for striped bass or shad fishermen from 1928 to 1931, as the price per pound paid to the fishermen dropped considerably during these years, as shown in table 8. It is understood that during the past season (1932) the price of striped bass dropped to as low as four cents per pound to hook and line fishermen.

TABLE 8

AVERAGE PRICES PAID TO FISHERMEN DURING APRIL AND MAY, 1928-1931

Year	April			May		
	Roe shad	Buck shad	Striped bass	Roe shad	Buck shad	Striped bass
1928	$0.05	$0.007	$0.138	$0.05	$0.005	$0.112
1929	.05	.005	.166	.05	.005	.13
1930	.06	.014	.10	.05	.005	.08
1931	.045	.01	.081	.03	.00	.052

EXPLANATION OF THE INCREASED BOAT CATCH

Scofield (1931, pp. 72-73) has shown that the commercial striped bass catch was made up almost entirely of 5 and 6-year fish. In the fall months, 23 per cent of the commercial catch were 5-year-olds and 62 per cent were 6-year-olds. During November-February, inclusive, 65 per cent were 5-year-olds and 24 per cent were 6-year-olds. While during March-May, inclusive, the catch was made up of 56 per cent of 5-year-olds and 29 per cent of 6-year-olds.

It is demonstrated in the present study (see fig. 3) that 1928 was a year of poor catches throughout the entire season. In 1929, the average daily boat catch increased due to the catches made in November and December. (See fig. 3.) Sixty-five per cent of these fish taken in November and December (1929) were 5-year-olds (4-year-olds in the preceding spring, so were not taken in any amounts in the early part of 1929). This group, evidently a result of a very successful spawning in 1924, first influenced the

commercial catch in November and December, 1929. The same group made up the catch (together with other groups in smaller amounts) in January-May, inclusive, 1930. In August and September, 1930, this same group comprised about 60 per cent of the catch as 6-year-olds. The catch of November and December, 1930, was again apparently predominated by 5-year-olds, evidently another successful spawning in the spring of 1925. This last group appeared to be extremely abundant for it accounted for most of the large catches made from January-May, inclusive, 1931, together with the preceding group. The catch for the first half of August, 1931, was not high, but from all indications, if a measure for the remainder of the season had been available the catch during August and September, 1931, would probably have been high, dominated as it presumably might have been by a very abundant group.

CONCLUSIONS

From this continuation of the previous work (Craig, 1930) on striped bass boat catch analysis, in which similar data and the same methods were employed as used by Craig in his work on the catches from 1920-1927, inclusive, the relative abundance of striped bass available to the fishermen has been calculated and is shown from 1920 to the end of legal netting operations (August 14, 1931). (See fig. 7.)

The total catch of striped bass was at its lowest point in 1928 (see fig. 1), but during the period 1929-1931, it increased each year until in 1931, the total catch of striped bass (including commercial hook and line caught bass after netting was prohibited on August 14) was greater than in any year since 1918.

As the total catch is not as a rule an accurate index to abundance, the catch data were recorded by boats and the average daily boat catch per year was obtained for each year from 1920 to August 14, 1931.[2]

The average daily boat catch was corrected for seasonal variations by obtaining the percentage deviations from a base year in which like seasonal parts were compared. The percentage deviation for each period was weighted by the normal number of catches occurring in that period in order to eliminate the influence of strikes, inclement weather of long duration, and other unusual conditions which might affect the fishery. Any influence that the shad catches might have had on the striped bass yield was shown to be of little consequence. The result (see fig. 7) was the percentage deviation from normal, using like seasonal periods weighted by an average number of catches for each period. These values presented in figure 7 represent the availability of striped bass to the fishermen from 1920 to August 14, 1931, as accurately as possible from the data available. The curve shows that the striped bass supply

[2] Catch data after this date are not comparable with previous records of commercial catches because net fishing for striped bass has been discontinued, although some commercial catches are made with hook and line.

undoubtedly was able to support the fishery up to the time the law went into effect prohibiting the taking of striped bass with nets. (However, striped bass taken accidentally while fishing for shad in District 12B between March 15 and April 30 may be sold.) It would appear that over

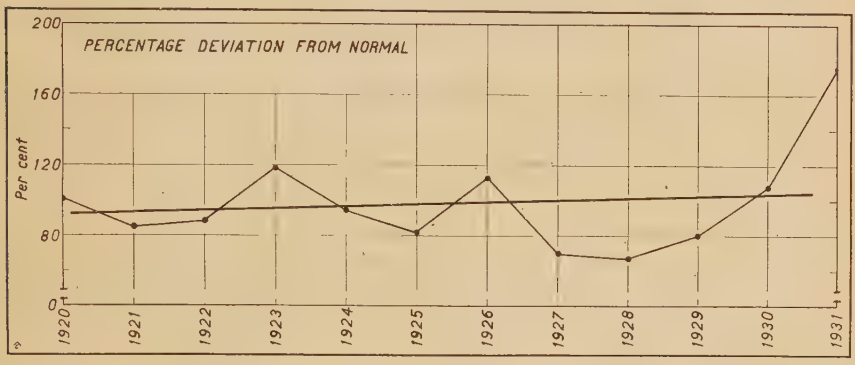

FIG. 7. The curve that best represents the striped bass available to the fishermen—the percentage deviation from the normal or average year weighted by the average number of catches. Notice the trend of the straight line fitted to the points.

the entire period of years, 1920–August 14, 1931, the striped bass population had supported a commercial fishery, and in later years, an intensive sport fishery, without endangering the supply. Whether or not the bass population will continue to support the fishery at the present level can not be predicted now. However, the fishery should be watched carefully and an analysis of the yield should be continued in the future. Inasmuch as commercial net fishing was abolished almost entirely by the law passed in 1931, some method should be devised so that the catch records of all hook and line fishermen (both commercial and sport) can be secured in order that some analysis of the catch can be made in the future.

From the work of Scofield (1931, pp. 72-73) it was demonstrated how successful spawnings of the striped bass to produce abundant year groups, could have accounted for the increase in the striped bass catches in the past three years (1929-1931).

It is the writer's opinion, in the light of this analysis, that if conditions affecting the striped bass were to remain the same as in the past few years, the striped bass population could support a commercial fishery as well as a sport fishery, but that any fishery must be watched from year to year in order to detect any significant changes in the yield.

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